

A growing commitment to future CO₂ emissions

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Perspective

A growing commitment to future CO₂ emissions

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Abstract

The construction of new fossil fuel energy infrastructure implies a commitment to burn fossil fuels and therefore produce CO₂ emissions for several decades into the future. The recent letter by Davis and Socolow (2014 *Environ. Res. Lett.* 9 084018) highlights the current and growing commitment to future emissions, and argues that this emission commitment should be accounted for at the time of new construction. The idea of accounting for future committed emissions associated with current energy policy decisions is compelling and could equally be applied to other aspects of the fossil fuel supply chain, such as investing in the development of new fossil fuel reserves. There is evidence, for example, that oil reserves are growing faster than the rate of extraction, implying a growing future emissions commitment that is likely incompatible with climate mitigation targets.

Keywords: fossil fuel reserves, CO₂ emissions, commitment accounting

There is growing evidence that global temperature change responds approximately linearly to cumulative CO₂ emissions. Consequently, we can define a quantity of allowable cumulative emissions (a global carbon emissions budget) for a given climate target [2–7]. An important implication of this idea is that while the temperature change produced by a given amount of CO₂ emissions is largely irreversible [8, 9], there is little additional future warming expected from CO₂ already in the atmosphere [10]. Consequently, future global warming will be driven primarily by CO₂ emissions that have not yet occurred [11].

However, our current dependence on fossil fuel energy infrastructure represents a societal commitment to continue to burn fossil fuels, and therefore to continue to produce CO₂ emissions. The inertia associated with technological change implies that some amount of future CO₂ emissions and temperature change will occur, regardless of how quickly we move as to develop non-CO₂ energy technologies. These committed future emissions were first quantified by Davis *et al* [12], and have been shown to comprise a substantial portion of the cumulative emissions budget that is required to maintain global warming below 2 °C [13].

The recent letter by Davis and Socolow [1] has now extended this analysis to show how the emissions commitment associated with fossil fuel energy technology has grown since the middle of the 20th century. The world is continuing to build new CO₂-producing energy infrastructure, and is doing so faster than the rate of retirement of old technology. This means that not only are annual emissions continuing to increase, but the future emissions commitment associated with this energy infrastructure is also increasing as a result of today's energy policy decisions [1].

Davis and Socolow's work presents a framework for how this emissions commitment could be accounted for at the time that decisions are made to build



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new CO₂-producing energy technology. Their analysis of this ‘commitment accounting’ focuses on power plants fueled by coal, natural gas and oil. In principle, however, the idea of commitment accounting could be applied to any investment in the use of fossil fuels as an energy source, from the installation of residential heating systems, to the construction of oil and gas pipelines, or even to the exploration for new fossil fuel reserves.

The financial investment in the construction of a new power plant generates an economic commitment to use this technology. Similarly, the investment in exploration for new fossil fuel reserves implies an intention to eventually extract and ultimately burn this fuel. The growth of a fossil fuel reserve base over time can therefore be considered to represent a commitment to future CO₂ emissions, whereas the extraction of fuel from that reserve represents the realization of those emissions. As long as the reserve base is growing faster than the rate of fuel extraction, the commitment to future CO₂ emissions from the use of this fuel will increase.

Using historical data on fuel reserves and extraction [14], it is possible to quantify how this commitment has changed over time (figure 1(A)). For the case of oil, global oil extraction from 1980 to 2013 totaled 120 billion tonnes (Gt), which using a conversion factor of 3.07 tonnes of CO₂ per tonne of oil [14], can be considered to represent realized emissions of approximately 370 Gt CO₂. Over this same period of time, however, the oil reserve base also increased by 137 Gt of oil, which means that the oil reserves on average grew over this time at more than twice the rate of oil extraction. Consequently, the commitment to future emissions from oil use increased by 420 Gt CO₂ since 1980. Given current (year 2013) proven oil reserves of 230 Gt of oil, the total potential for future emissions from this reserve is about 700 Gt CO₂.

The linear relationship between cumulative CO₂ emissions and temperature change then enables an estimate of the future warming that would occur if this fuel were used. Using a best estimate of 0.4 °C per 1000 Gt CO₂ [6, 7], this means that: (1) oil extraction since 1980 represents 0.15 °C of global temperature change which has already occurred; (2) the growth of oil reserves since 1980 represents an additional potential warming of 0.17 °C that has not yet occurred; and (3) full combustion of the current oil reserve would represent 0.28 °C of future global warming.

What about other fossil fuel reserves? Using similar data and conversion factors for natural gas and coal [14], there are currently 390 Gt CO₂ in proven natural gas reserves¹, and 1700 Gt CO₂ in coal². Were we to burn this entire reserve base, this would lead to 0.16 °C of warming from natural gas, and 0.68 °C from coal. Combined with oil (0.28 °C), this results in a total of 1.12 °C of potential future warming from current fossil fuel reserves (figure 1(B)). This by itself, ignoring all other contributions to climate change, would bring the world very close to 2 °C of total global warming.

These calculations are of course approximate, and are subject to large uncertainty in both estimates of fossil fuel reserve sizes, as well as in the climate response to CO₂ emissions. However, it is nevertheless a useful exercise to think about how historical and current exploration for new fossil fuel reserves represents an economic investment in and therefore commitment to burn this fuel in the future. As in the case of Davis and Socolow’s power plant analysis, we are currently expanding the fossil fuel reserves faster than the rate of fuel extraction, leading to an increasing commitment to future CO₂ emissions. Given the amount of carbon and potential emissions contained in the much larger fossil fuel resource base, our analysis suggests that continuing to invest in exploration and extraction

¹ Calculated using BP’s estimate for natural gas reserves (186 trillion m³), and converted to CO₂ using: (1) 0.9 tonnes of oil equivalent per 1000 m³ natural gas; and (2) 2.35 tonnes of CO₂ per tonne of oil equivalent [14].

² Calculated using BP’s estimates for coal reserves (403 Gt of hard coal, 488 Gt of lignite) and converted to CO₂ using: (1) 1 tonne of oil equivalent = 1.5 and 3 tonnes of hard coal and lignite, respectively; and (2) 3.96 tonnes of CO₂ per tonne of oil equivalent [14].

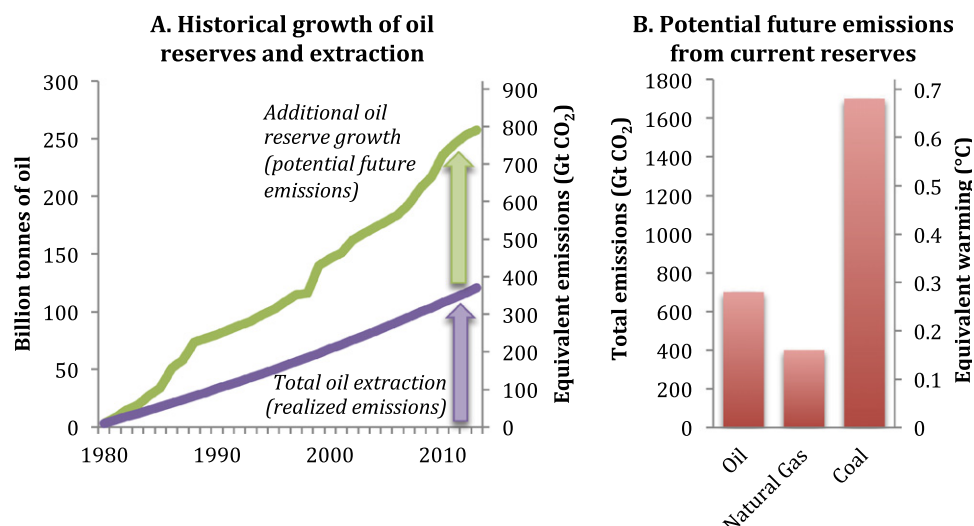


Figure 1. (A) Growth of oil reserves since 1980 (green line) represent additional potential future emissions above those already realized from oil extraction (purple line). (B) Current proven reserves of oil, natural gas and coal represent a commitment to future potential emissions (left axis) and additional climate warming (right axis) should these reserves be extracted and burnt. This estimate of committed climate warming is based on a central value for the climate response to cumulative CO₂ emissions (0.4 °C per 1000 Gt CO₂) [6, 7], which is of course subject to substantial uncertainty associated with the physical climate and carbon cycle sensitivities to emissions.

technologies to expand current proven reserves is inconsistent with a 2 °C climate target. Instead, we will very likely need to decrease the current commitment to future CO₂ emissions by leaving some economically viable fossil fuel reserves in the ground.

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